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Effect of Dietary Salmon Protein Concentrate on Growth Performance of Broiler Chickens

A.S. Leaflet R2220

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Summary and Implications

In this study, 480 male broiler chicks were used to determine the effects of dietary dried and condensed salmon protein concentrate (SPC) on growth performance. The data presented herein showed that feeding a corn–soybean meal diet containing 11.5% condensed SPC increased the rate of body weight gain by as much as 12% compared to the control diet, whereas dried SPC did not appear to elicit similar growth performance enhancements compared with that of a control diet or a menhaden fishmeal diet.

Introduction

The intestines of broiler chicks and turkey poults are not fully developed at hatch, taking 10–14 days before nutrient digestibility and energy utilization are maximized. To counter the young animals' limited abilities to digest plant-derived feed ingredients, starter diets typically include high-quality and sometimes immune-enhancing feed ingredients and additives (e.g., fishmeal, spray-dried plasma protein, antibiotic growth promoters). The special processing techniques employed in the manufacturing of SPC preserve the inherently high-quality nutrients in the natural Alaskan wild salmon. Moreover, the long-chain omega-3 (ω-3) fatty acids, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), found in high amounts in certain fish oils, generally improve calcium absorption, bone strength, development of brain function and cognition, and health status. In short, SPC is a high-quality feed ingredient with immune-enhancing properties that has the potential to promote growth in young, immature animals, such as broiler chicks.

Material and Methods

Chemical Analysis of Feedstuffs

Chemical analysis of dried and condensed salmon meal and menhaden fishmeal was performed on representative samples prior to diet formulation (Table 1). Prior to chemical analysis, the condensed SPC was freeze-dried and all analyses performed on the freeze-dried material. The content of total amino acids were analyzed by ion-exchange chromatography, whereas the content of available lysine was estimated by the 1-fluoro-2,4-dinitrobenzene (DNFB) method.

Dietary Treatments

All diets were based on corn and soybean meal and formulated to meet or exceed the National Research Council (1994) nutrient recommendations (Table 2). The experimental diets were formulated using analyzed amino acid values for corn, soybean meal, condensed and dried SPC, and menhaden fishmeal. Menhaden fishmeal (Special Select Menhaden Meal; Omega Protein Corporation, Houston, TX) was included at 5.0% in the positive control diet. Dried and condensed SPC (Alaska Protein Recovery, Juneau, AK) were added to supply equal amounts of total lysine as that of the menhaden fishmeal. Hence, the condensed SPC diet contained 11.5% condensed SPC, whereas the dried SPC diet contained 5.2% dried SPC. Moreover, a diet containing 2.6% dried SPC (i.e., half of that in the 5.2% SPC diet) and a negative control diet, containing no fishmeal, were included among the dietary treatments. All broiler diets contained a coccidiostat (90 g/ton of monensin). The 5 dietary treatments were fed from 0–3 weeks of age (Starter phase) and a common diet was fed from 3–6 weeks of age (Finisher phase).

Housing and Management

A total of 480 1-day-old male broiler chicks (Ross × Ross 308) were obtained from a commercial hatchery. Upon arrival, the chicks were weighed and allotted to floor pens (1.2 × 1.2 m) according to a randomized complete block design. Each pen contained 12 chicks and was equipped with 1 plastic self-feeder and 5 water nipples. The litter consisted of 16-week-old soiled litter (pine shavings) from an on-site broiler barn, thus creating a relatively unsanitary environment in which any immune-enhancing effects of the ω-3 fatty acids in the SPC would be evident. The broilers had free access to feed and water at all times throughout the experiment. Body weights and feed consumption (measured as feed disappearance) were recorded weekly and the feed utilization calculated as the gain-to-feed ratio.

Statistical Analyses

All data were subjected to analysis of variance (ANOVA) procedures appropriate for a randomized complete block design using JMP 5.1 (SAS Institute, Gary, NC) with 8 blocks (replications). The effects on growth performance of the dietary treatments were evaluated using Fisher's protected least significant difference. Pens served as experimental units and P-values less than or equal to 0.05 were considered significant.

Results

Body Weight Gain

During weeks 1, 2, and 3 and throughout the Starter phase, broilers fed the condensed SPC grew faster ($P < 0.05$) than broilers fed the control or dried SPC diets (Table 3). The broilers fed menhaden fishmeal had intermediate rates of gain. As a result of the faster rate of gain, broilers fed condensed SPC were heavier ($P < 0.05$) at the end of Weeks 1, 2, and 3 compared with broilers fed the control or dried SPC diets, while those fed menhaden fishmeal were of intermediate weight.

No differences in rate of gain were seen in any of the weeks during the Finisher phase except Week 6, when the control-fed broilers gained weight faster ($P < 0.05$) those fed 5.2% dried SPC. However, the broilers previously fed condensed SPC maintained higher body weights than broilers fed any other diet ($P < 0.05$) except at the end of Week 6, when they were only heavier than broilers consuming either dried SPC diet.

Feed Consumption

During Weeks 1, 2, and 3 and throughout the Starter phase, broilers fed condensed SPC consumed more feed ($P < 0.05$) than broilers fed the control or dried-SPC diets, whereas the menhaden fishmeal treatment generally resulted in intermediate feed consumption rates (Table 4).

During Week 4, broilers fed condensed SPC in the Starter phase consumed more feed than control broilers ($P < 0.05$), but no other differences were seen ($P > 0.05$). In Weeks 5 and 6 and throughout the Finisher phase, however, feed consumption was not effected by dietary treatment ($P > 0.05$). Throughout the entire 6-week-long study, broilers fed condensed SPC consumed more feed than both levels of dried SPC and the control ($P < 0.05$).

Feed Utilization

Feed utilization was only affected during Weeks 2 and 3. During Week 2, broilers fed 5.2% dried SPC utilized feed more efficiently ($P < 0.05$) than control-fed birds (Table 5). During Week 3, however, those fed condensed SPC had higher feed utilization ($P < 0.05$) than those fed 2.6% dried SPC. Feed utilization was not affected by diet throughout either the Starter or Finisher phase, or throughout the entire study.

Discussion

Fast, initial growth by young chicks can have major impacts on broiler performance later on in life. The use of highly digestible nutrients in starter diets may help young chicks improve early growth performance. Lysine is especially sensitive to heat damage due to its reactive epsilon amino group. However, the drying conditions of the SPC were sufficiently gentle to only cause a minimal reduction in the content of reactive lysine, indicating that the protein quality of both condensed and dried SPC is very high and higher than that of menhaden fishmeal. The processing procedures employed in manufacturing SPC help ensure that the inherently high-quality nutrients in the salmon remain bioavailable. Indeed, the condensed SPC diet resulted in up to 12% faster rate of body weight gain than the control, dried-SPC, and menhaden fishmeal diets. The faster rate of gain was likely due to the higher feed consumption, because feed utilization was not affected. However, because all diets were balanced to contain equal contents of the first- and second-limiting amino acids (methionine+cystine and lysine, respectively), potential differences in nutrient digestibility and bioavailability, indicated by the higher contents of available lysine, may have been at least partially responsible for the improved growth rate. In addition, the contents of ω-3 fatty acids may have helped down-regulate the immune and inflammatory responses likely seen in the unsanitary environment, which would further enhance growth performance. However, more research is needed to firmly establish the potential health benefits of dietary SPC.

It should be noted that the diet containing the condensed SPC tended to bridge and stick to the feeders and became slightly moldy.[1] This adverse effect was likely due to the high moisture content of the condensed SPC and the high temperatures in the broiler house. If this product is to be used more extensively, it needs to be made more stable to avoid mold formation or the feed should be mixed more often, thus avoiding storage of the mixed feed.

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[1] It is unlikely that the adverse physical effects of condensed SPC had an impact on broiler performance, because the broilers fed condensed SPC gained body weight at a faster rate and utilized feed more efficiently than those fed the dried SPC and the control diet.

Table 1. Analyzed chemical composition of the fishmeals.[1]

Item	Dried SPC		Condensed SPC		Menhaden fish meal	
	As-is basis	Dry matter basis	As-is basis	Dry matter basis	As-is basis	Dry matter basis
	%					
Dry matter	95.7	100.0	41.3	100.0	93.8	100.0
Crude protein	64.5	67.3	28.0	67.8	63.9	68.1
Ether extract	11.1	11.6	4.4	10.6	8.5	9.1
Ash	16.2	16.9	6.9	16.8	20.6	21.9
Calcium	0.39	0.42	0.18	0.42	5.28	5.72
Phosphorus	3.87	4.14	1.82	4.41	3.11	3.37
Sodium	1.17	1.27	0.55	1.33	0.71	0.77
Chlorine	1.94	2.10	0.89	2.15	0.90	0.98
Alanine	3.85	4.02	1.72	4.16	3.97	4.23
Arginine	3.99	4.17	1.80	4.36	3.77	4.02
Aspartate+asparagine	5.18	5.97	2.31	5.40	5.60	5.92
Glutamate+glutamine	7.11	7.43	3.17	7.66	7.98	8.50
Glycine	5.11	5.33	2.28	5.52	4.70	5.01
Histidine	1.60	1.67	0.71	1.72	1.68	1.79
Isoleucine	2.59	2.70	1.04	2.52	2.55	2.72
Leucine	4.08	4.26	1.81	4.38	4.43	4.72
Lysine	4.61	4.81	2.05	4.97	4.87	5.19
Hydroxylysine	0.22	0.23	0.10	0.24	0.27	0.28
Methionine	1.54	1.61	0.68	1.64	1.74	1.86
Cysteine	0.48	0.50	0.23	0.56	0.50	0.53
Cystine[2]	0.24	0.25	0.12	0.28	0.25	0.27
Methionine+cystine	1.78	1.87	0.80	1.92	1.95	2.13
Phenylalanine	2.30	2.40	1.00	2.42	2.58	2.74
Proline	2.89	3.02	1.28	3.09	2.82	3.01
Hydroxyproline	0.80	0.84	0.37	0.90	0.97	1.03
Ornithine	0.38	0.40	0.16	0.40	0.13	0.14
Serine	2.33	2.43	1.09	2.63	2.23	2.38
Threonine	2.42	2.53	1.10	2.65	2.50	2.66
Tryptophan	0.46	0.48	0.19	0.47	0.64	0.68
Tyrosine	1.95	2.04	0.90	2.18	2.01	2.14
Valine	2.98	3.11	1.29	3.12	2.98	3.18
Available lysine[3]	4.49	4.69	2.03	4.90	4.57	4.87
Available lysine, % of total lysine	97.3	97.5	99.0	98.6	93.8	93.8

[1]Abbreviations used: SPC, salmon protein concentrate.
[2]One molecule of cystine consists of two molecules of cysteine bound together with a disulfide bond.
[3]A measure of bioavailable (i.e., non–heat-damaged) lysine.

Table 2. Composition of experimental and common diets.[1,2,3]

Item	Starter					Finisher
	Control	2.5% Dried SPC	5.2% Dried SPC	11.5% Condensed SPC	5% Menhaden	
	%					
Composition						
Dried salmon meal	—	2.60	5.20	—	—	—
Condensed salmon meal	—	—	—	11.50	—	—
Menhaden fishmeal	—	—	—	—	5.00	—
Corn	51.27	53.77	56.47	44.40	57.31	57.12
Soybean meal (48%)	39.90	35.80	31.50	32.50	31.20	34.40
Soybean oil	4.31	3.61	2.88	7.64	2.71	4.19
Dicalcium phosphate	1.73	1.22	0.72	0.72	1.80	1.55
Limestone	1.33	1.62	1.91	1.91	0.65	1.33
Salt, iodized	0.47	0.39	0.32	0.31	0.38	0.47
DL-Methionine	0.26	0.26	0.27	0.29	0.22	0.21
Trace mineral premix[4]	0.30	0.30	0.30	0.30	0.30	0.30
Vitamin premix[5]	0.35	0.35	0.35	0.35	0.35	0.35
Coban 60[6]	0.08	0.08	0.08	0.08	0.08	0.08
Total	100.00	100.00	100.00	100.00	100.00	100.00
Calculated composition						
Dry matter	88.16	88.18	88.18	83.13	88.02	87.96
Crude protein	22.90	22.81	22.64	22.12	22.37	20.68
Metabolizable energy, Mcal/kg	3.05	3.05	3.05	3.05	3.05	3.10
Calcium	1.00	1.00	1.00	1.00	1.00	0.95
Phosphorus, non-phytate	0.45	0.45	0.45	0.45	0.45	0.41
Sodium	0.20	0.20	0.20	0.20	0.20	0.20
Chloride	0.32	0.32	0.33	0.32	0.31	0.32
Arginine	1.55	1.52	1.49	1.48	1.46	1.38
Histidine	0.59	0.59	0.58	0.57	0.58	0.54
Isoleucine	0.96	0.95	0.93	0.91	0.92	0.86
Leucine	1.89	1.87	1.84	1.77	1.85	1.74
Lysine	1.30	1.30	1.30	1.30	1.30	1.15
Methionine	0.58	0.60	0.62	0.63	0.58	0.51
Methionine+cystine	0.94	0.94	0.94	0.94	0.94	0.83
Phenylalanine	1.17	1.14	1.10	1.08	1.11	1.05
Threonine	0.89	0.88	0.87	0.86	0.86	0.80
Tryptophan	0.30	0.28	0.27	0.27	0.28	0.26
Valine	1.04	1.04	1.03	1.01	1.02	0.94

[1]Values represent percent of diet on an as-is basis.

[2]Abbreviations used: SPC, salmon protein concentrate.

[3]Broilers were fed the experimental diets during the starter phase (0–3 weeks of age). During the finisher phase (3–6 weeks of age), all broilers were fed a common corn–soybean meal based diet.

[4]Supplied per kilogram of diet: Manganese, 70 mg; zinc, 90 mg; iron (ferrous sulfate), 60 mg; copper, 12 mg; selenium (sodium selenite), 0.15 mg; sodium chloride, 2.5 g.

[5]Supplied per kilogram of diet: Vitamin A, 9259 IU; vitamin D_3, 3086 ICU; vitamin E, 15 IU; vitamin B_{12}, 0.012 mg; riboflavin, 6 mg; niacin, 31 mg; D-pantothenic acid, 11 mg; choline, 386 mg; vitamin K, 2 mg; folic acid, 0.5 mg; vitamin B_6, 2 mg; thiamine, 2 mg; D-biotin, 0.05 mg.

[6]Supplied per 907 kg of diet: Monensin, 90 g.

Table 3. Average daily body weight gain of broilers fed salmon protein concentrate (SPC) or menhaden fishmeal.[1,2]

Week or phase	Diet					SEM[3]
	Control	2.6% Dried SPC	5.2% Dried SPC	11.5% Condensed SPC	5% Menhaden	
	g/day					
1	16.0^{B}	15.8^{B}	16.0^{B}	17.3^{A}	16.6^{AB}	0.3
2	34.3^{c}	36.0^{bc}	35.9^{bc}	39.1^{a}	37.3^{b}	0.6
3	66.8^{c}	67.5^{bc}	66.5^{c}	72.8^{a}	69.0^{b}	0.8
4	79.6	81.2	79.9	82.2	81.0	0.9
5	104.0	103.6	107.8	104.7	102.0	3.1
6	97.6^{a}	89.6^{ab}	85.2^{b}	90.6^{ab}	95.8^{ab}	3.7
Starter	39.3^{c}	39.7^{bc}	39.5^{c}	43.1^{a}	40.9^{b}	0.5
Finisher	93.7	91.4	90.9	92.5	92.9	1.2
Overall	66.5^{ab}	65.6^{b}	65.2^{b}	67.8^{a}	66.9^{ab}	0.7

[1]Broilers were fed the experimental diets during the starter phase (0–3 weeks of age). During the finisher phase (3–6 weeks of age), all broilers were fed a common corn–soybean meal based diet.
[2]Values are means of 8 pens, each containing 12 broilers, per dietary treatment.
[3]Pooled standard error of the mean.
[abc]Means with different superscripts within the same row are different ($P < 0.05$).
[AB]Means with different superscripts within the same row are different ($P < 0.01$).

Table 4. Average daily feed consumption of broilers fed salmon protein concentrate (SPC) or menhaden fishmeal.[1,2]

Week or phase	Diet					SEM[3]
	Control	2.6% Dried SPC	5.2% Dried SPC	11.5% Condensed SPC	5% Menhaden	
	g/day					
1	21.2^{b}	22.0^{b}	21.1^{b}	23.8^{a}	22.5^{ab}	0.6
2	46.6^{c}	47.6^{bc}	46.0^{c}	51.5^{a}	49.1^{b}	0.7
3	89.1^{c}	90.8^{bc}	88.5^{c}	95.2^{a}	91.8^{b}	0.8
4	123.7^{b}	125.4^{ab}	124.2^{ab}	127.7^{a}	126.1^{ab}	1.0
5	172.3	172.6	170.3	174.8	171.8	1.7
6	184.4$^{\#}$	178.2$^{\#}$	179.1$^{\#}$	181.6	184.3	2.0
Starter	52.1^{c}	53.4^{bc}	51.7^{c}	56.8^{a}	54.3^{b}	0.6
Finisher	160.0	158.7	157.8	161.3	160.6	1.3
Overall	105.7^{bc}	105.9^{bc}	104.5^{c}	108.9^{a}	107.1^{ab}	0.8

[1]Broilers were fed the experimental diets during the starter phase (0–3 weeks of age). During the finisher phase (3–6 weeks of age), all broilers were fed a common corn–soybean meal based diet.
[2]Values are means of 8 pens, each containing 12 broilers, per dietary treatment.
[3]Pooled standard error of the mean.
[abc]Means with different superscripts within the same row are different ($P < 0.05$).
[#]Linear effect was seen of increasing amount of dried SPC in the diet ($P < 0.05$).

Table 5. Feed utilization of broilers fed salmon protein concentrate (SPC) or menhaden fishmeal.[1,2]

Week or phase	Diet					SEM[3]
	Control	2.6% Dried SPC	5.2% Dried SPC	11.5% Condensed SPC	5% Menhaden	
	g gain/kg feed					
1	756	721	764	728	738	17
2	738[b]	758[ab]	782[a]	758[ab]	759[ab]	12
3	750[ab]	744[b]	752[ab]	765[a]	752[ab]	8
4	643	648	643	644	642	4
5	603	600	632	599	594	16
6	529	502	476	499	520	18
Starter	755	745	765	758	753	9
Finisher	586	576	576	574	579	6
Overall	629	619	624	623	625	5

[1]Broilers were fed the experimental diets during the starter phase (0–3 weeks of age). During the finisher phase (3–6 weeks of age), all broilers were fed a common corn–soybean meal based diet.

[2]Values are means of 8 pens, each containing 12 broilers, per dietary treatment.

[3]Pooled standard error of the mean.

[ab]Means with different superscripts within the same row are different ($P < 0.05$).